

# APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention: PROTECTIVE RING FOR THE FAN PROTECTIVE CASING OF A GAS  
TURBINE ENGINE

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This is a:

- ☐ Provisional Application
- ☒ Regular Utility Application
- ☐ Continuing Application  
\_\_\_\_ The contents of the parent are  
incorporated by reference
- ☐ PCT National Phase Application
- ☐ Design Application
- ☐ Reissue Application
- ☐ Plant Application

## SPECIFICATION

**PROTECTIVE RING FOR THE FAN PROTECTIVE  
CASING OF A GAS TURBINE ENGINE**

This application claims priority to German Patent Application  
5 DE10259943.3 filed December 20, 2002, the entirety of which is  
incorporated by reference herein.

**BACKGROUND OF THE INVENTION**

This invention relates to a protective ring for a fan protec-  
10 tive casing of a gas turbine engine in the form of a full con-  
tainment or in the form of a penetration containment with  
trapping layer.

During take-off with maximum power demand, the fan of an air-  
15 craft jet engine is subject to the highest loads which, under  
extreme conditions, may lead to a failure of the fan blades,  
for example if large birds or objects on the runway are in-  
gested by the fan and strike the fan with high kinetic energy.  
If such an event occurs, any broken-off fan fragments must  
20 absolutely be precluded from breaking through the engine  
casing in order to avoid serious consequences to the aircraft  
itself. In order to avoid destruction of the engine, a special  
type of fan protective casing or protective ring, also  
referred to as a containment, is provided around the  
25 particularly endangered casing area on the outer circumference  
of the fan.

Depending on their design and function, distinction is made  
between two types of protective casings, namely the full con-  
tainment and the penetration containment.

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The full containment is designed such that a failed fan blade  
or a blade fragment, while being allowed to cause deformation

of the protective ring, will not be able to break through the protective ring. It will finally be discharged from the engine via the by-pass duct without bringing about further damage. This solution, while being functionally favorable, has the disadvantage of high weight, resulting from the compact metal ring of which such a protective casing consists.

A known design of penetration containment comprises a thin-walled metal ring through which the failed fan fragment can break, but with the fan fragment being retained by a weave arranged on the outer circumference of the metal ring, the so-called trapping layer. The penetration containment, which is definitely lighter than and in this respect, superior to the full containment, is, however, problematic in that, upon breakthrough, the damaged fan wheel, which now runs out of balance, will generate vibrations in the engine casing. This can result in an increase of the cracks existing at the point of breakthrough on the metal ring and in corresponding consequential damage.

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In the case of a penetration containment described in Specification US 4 699 567, a rigid, thin-walled cylinder made of light metal or fiber-reinforced resin is initially covered with woven fiber-material layers consisting of single material pieces, with the inner layers so formed being wrapped with further fiber-material layers of continuous strip length. The outer surface of the containment is covered with an impermeable metallic or non-metallic protective layer. If a flinging blade fragment breaks through the inner ring (metallic protective ring), it will on its route be first enclosed and padded by the inner fiber-material pieces and finally be caught by the outer, continuous fiber-material layers, these absorbing

the impact energy by elastic deformation. A further propagation of the damage existing in the rigid protective ring of the containment can, however, not be avoided.

5 In a fan casing structure known from Specification US 5 486 086, an inner, rigid safety cylinder (protective ring), which surrounds the fan blades at a certain distance, is provided on the outer surface with a plurality of ribs extending in the longitudinal and circumferential direction,  
10 these ribs being intended to prevent the propagation of cracks beyond the rib-reinforced material zones.

#### BRIEF SUMMARY OF THE INVENTION

The present invention, in a broad aspect, provides a protective ring for the fan wheel of a gas turbine engine which, as  
15 a full containment, has a high impact-absorption capacity and a lower weight than the known designs and, as a penetration containment, prevents the cracks or holes produced in the penetration area from propagating or growing.

20 It is a particular object of the present invention to provide solution to this problem by way of a protective ring designed according to the description herein. Further objects and advantages of the present invention will be apparent from the  
25 description below.

The idea underlying the present invention is that the protective ring, which is arranged remotely of the outer circumference of the fan, includes an alternation of several strata of  
30 sheet-metal bands and polymer-bonded fiber weave layers. Instead of sheet metal, the inner metallic bands can also include a metal weave. According to the number of strata, the

protective ring can either be applied as a full containment, in which case it is provided with a sufficiently large wall thickness, or as a penetration containment, in which case it is provided with a smaller wall thickness and with a trapping  
5 layer arranged on the outer circumference. As a full containment, the protective ring has tough-elastic properties enabling it to absorb any impact of fan blade fragments without destruction of the protective ring material. As a penetration  
10 containment, a breakthrough of the protective ring with its small wall thickness is deliberately accepted, with the fragments finally being retained in the trapping layer.

Owing to the material combination in accordance with the present invention of thin sheet-metal layers and polymer-  
15 bonded fiber layers in alternating arrangement and in intimate adhesive bond, a growth of the holes and cracks in the protective ring, as well as consequential damage to engine and aircraft, can be excluded, despite the imbalance of the damaged fan disk and the correspondingly high mechanical load.  
20 A further, major advantage of this type of protective ring is the considerable weight savings, both in its form as a penetration containment and, especially, in its form as a full containment.

For the production of a closed protective ring, the ends of  
25 the respective metal bands are lap-bonded by means of an adhesive, while the fiber-weave layers extend continuously between the opposite ends of adjacent metal bands. This ensures the intended properties and an intimate bond also at the joint. In order to obtain large wall thicknesses of the protective ring,  
30 a material strip of smaller thickness can also be wound to a protective ring, or two or more protective rings with matching

inner and outer diameters can be put into each other and bonded at the mating faces.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5 The present invention is more fully described in the light of the accompanying drawings showing an embodiment. In the drawings,

Fig. 1 is a sectional view of the air intake area of a gas turbine engine in schematic representation,  
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Fig. 2 is a detail view Z of Fig. 1 showing a section through the wall of a penetration-protection ring (penetration containment) in schematic representation,  
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Fig. 3 is a detail view X of Fig. 1 showing a section through the wall of a full-protection ring (full containment) in schematic representation, and  
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Fig. 4 is an enlarged representation of the composite material provided for the protective ring at the joint of the ends.

#### DETAILED DESCRIPTION OF THE INVENTION

25 Fig. 1 shows the air intake area of a gas turbine engine, in particular a fan wheel rotating in an engine casing 1, with the fan wheel including a fan disk 2 and the fan blades 3 carried by this disk. For the protection of the engine casing and  
30 the engine, a protective ring (containment) 4 is provided on

the inner circumference of the engine casing 1 in the area above the fan blades 3. If an object, for example a large bird, should strike a fan blade 3 and cause the fan blade 3 to fail, an event which is more likely in the take-off phase, the protective ring 4 will preclude the fan blade fragments from destroying the engine or the engine casing. For simplicity reasons, the protective ring 4 is shown in Fig. 1 both as a multi-part full-protection ring or full containment 4' (detail X) and as a penetration containment 4'' (detail Z). Actually, either a circumferential full-protection ring (as full containment 4') or a circumferential penetration-protection ring with trapping provision (as penetration containment 4'') can be arranged remotely beyond the ends of the fan blades 3.

Arranged between two flanges 5, the penetration containment 4'' comprises a penetration sleeve 6 made of several material layers and a trapping layer 7 including woven and/or knitted fiber material layers applied to the outer circumference of the protective ring 4. As fiber material, aromatic polyamide fibers are used, preferably commercial fiber materials known as KEVLAR.

While the fragments of a failed fan blade 3 may break through the penetration sleeve 6 (protective ring) in this embodiment, they will be caught by the fiber material of the trapping layer 7 and thus precluded from causing consequential damage. The main point is that the propagation or growth of the cracks or holes produced by the fan blade fragments breaking through the penetration sleeve 6 is avoided, despite the considerable imbalance of the fan wheel caused by a fan blade failure. Such an increase of the cracks or holes is avoided by a special design of the penetration sleeve 6 in a material combination

which, as shown in Fig. 4, includes an alternation of several metal bands 8 and polymer-impregnated fiber-weave layers 9. The high mechanical load imposed on the penetration sleeve 6 by the imbalance of the fan wheel after the above-mentioned damage will be elastically taken up by the thin metal bands 8 (8.1, 8.2, 8.3) and the fiber-weave layers 9 (9.1, 9.2), with any cracks and holes being elastically held together or bridged by the transverse fibers of the fiber-weave layers 9 which permit no, or only very slow, propagation of cracks.

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Fig. 4 shows a sectional view of a part of a penetration sleeve 6 at the joint of its two ends. As can be seen, the ends of the respective metal bands 8 overlap, while the fiber-weave layers 9 extend continuously also at the joint and passes through the adhesive-filled space between two opposite ends of different metal bands 8.1 and 8.2 or 8.2 and 8.3, respectively. This means that the overlapping, or opposite, metal band ends are bonded by an adhesive 10.

20 In the embodiment here shown, the penetration sleeve 6 includes five layers, namely three metal bands 8.1, 8.2 and 8.3 and two fiber-polymer-composite layers 9.1 and 9.2. However, the outer and inner layer will preferably be metal bands 8.1, 8.3 which also act as a humidity barrier. The penetration sleeve 6 can be manufactured in different thicknesses by adding or subtracting layers to provide the desired strength for specific applications.

30 In the case of the full containment 4' embodiment (full-protection ring) shown in Fig. 3 (detail X in Fig. 1), the trapping layer 7 has been omitted. Instead, the wall thickness of the penetration sleeve 6 and, accordingly, the number of



alternating metal bands and polymer-impregnated fiber-weave layers is selected such that the protective ring 4 will not be broken through by the fan blade fragments, these being discharged rearward via free passages 11 of the engine. Thus, the penetration sleeve 6 will be thicker than in the embodiment of Fig. 2. This additional thickness of the penetration sleeve can be obtained by adding layers to a single penetration sleeve 6.

Alternatively, a winding process can be used to provide the required thickness. For instance, to obtain the wall thickness required for the protective ring 4 for a full containment 4' and still provide for formability when making the ring, a thin, just easily deformable material strand can be wound to obtain a penetration sleeve 6 for a full-protection ring with the required wall thickness. In another alternative, two or more individual penetration sleeves 6 each having thinner wall thicknesses but sized with correspondingly matching diameters so as to be able to nest in one another can be assembled together to provide the overall thickness required, as shown with the three penetration sleeves 6 of Fig. 3, but as discussed, a single penetration sleeve 6 can also be used as long as it has the desired thickness.

The protective ring 4 (full-protection ring) thus made, while being significantly lighter than the known full-protection rings, absorbs the impacts produced by the impinging blade fragments and cushions them off elastically. A growth of any impact-caused cracks as a result of the imbalance of the engine caused by the damage and fracture will, however, be precluded by the elastic, polymer-bonded fiber-weave layers intimately bonded to the metal bands.

Various aspects of the different embodiments can be combined in different manners to create new embodiments.